U.S. Higher Education in S&E

A key challenge for the higher education system in the United States is to remain a leader "in generating scientific and technological breakthroughs and in preparing workers to meet the evolving demands for skilled labor" (Greenspan 2000). The needs of the workplace are changing in today's information- and service-oriented economy; all workers require increased competency in mathematics and critical thinking and, at minimum, an understanding of basic science and technology concepts (Romer 2000). Despite the rising number of college-age adults (see "Demographics and Higher Education"), the National Science and Technology Council (NSTC 2000) has expressed concern about the nation's ability to meet its technical workforce needs and to maintain its international position in S&E. This section explains demographic trends that may affect higher education in the United States as well as institutional resources, both traditional and emerging, that are being mobilized to meet this challenge. The section includes data on the growing enrollment in S&E degree programs and the production of S&E degrees by type of institution. The growing importance of community colleges in lifelong learning and their role in teaching IT are also described.

Demographics and Higher Education

Past Trends

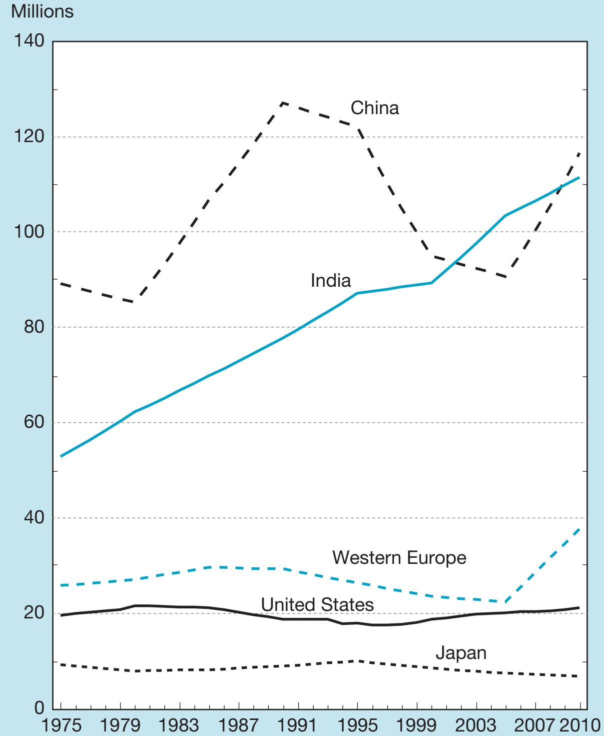
The size of the college-age cohort has decreased in all major industrialized countries, although within somewhat different time frames. The U.S. college-age population decreased from 22 million in 1980 to 17 million in 1997, a reduction of 23 percent. Europe's college-age population has begun an even steeper decline, from 30 million in 1985 to a projected 22 million in 2005, a reduction of 27 percent. Japan's college-age population of 10 million, which began to decline in 1995, is projected to reach a low of 7 million in 2010, representing a loss of 30 percent. (See appendix table 2-1.)

Based on these trends, the major industrialized countries have recruited foreign students to help fill their graduate S&E departments. See "International Comparisons of Foreign Student Enrollment in S&E Programs" at the end of this chapter. Most of these foreign students have been drawn from developing countries with far larger populations of potential college students. For example, China and India are major countries of origin for foreign graduate students in the United States, each with approximately 90 million in their college-age cohort. (See figure 2-1.)

Current Trends

In the United States, the almost 20-year decline of the college-age cohort reversed in 1997 and is projected to increase from 17.5 million to 21.2 million by 2010, with strong growth among minority groups. (See appendix tables 2-1 and 2-2.) This projected increase in the college-age population by more than 13 percent in the first decade of the 21st century, coupled with the high percentage of the college-age population electing to attend college, signals another wave of expansion in enrollment in the U.S. higher education system and growth in S&E degrees at all levels.

Figure 2-1.
Trends in population of 20- to 24-year-olds in selected countries and regions: 1975–2010



See appendix table 2-1. *Science & Engineering Indicators – 2002*

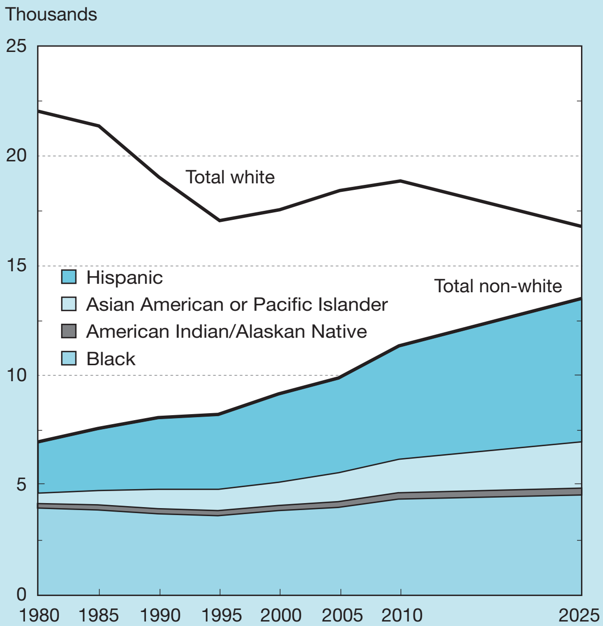
Demographic trends show an increase in the minority group population in the United States. (See figure 2-2.) The white college-age population will expand slowly until 2010 and then decline, whereas the college-age population of racial and ethnic minorities will continue to rise. These trends offer a challenge to the United States and an opportunity to educate students who have been traditionally underrepresented in S&E fields (e.g., women, blacks, Hispanics, and American Indians/Alaskan Natives).

Characteristics of U.S. Higher Education Institutions

The defining characteristics of the U.S. higher education system include broad access to an array of institution types and sizes with public and private funding and flexible attendance patterns. New ways of acquiring advanced training and skills outside these institutions are augmenting access (see "New Modes of Delivery"). As other countries broaden their access to higher education, a wider array of institution types and attendance patterns is also evolving internationally.

U.S. higher education includes nearly 3,400 degree-granting colleges and universities serving 14.5 million students, nearly 80 percent of whom attend public institutions. In 1997, approxi-

Figure 2-2.
U.S. population of 18- to 24-year-olds, by race/ethnicity: 1980–2025



See appendix table 2-2. *Science & Engineering Indicators – 2002*

mately 5.5 million of these students attended two-year institutions. Institutions of higher education at all levels awarded 2.2 million degrees in 1998, almost one-quarter of which were in S&E fields. (See figure 2-3.) Less than 8 percent of all students are enrolled in private liberal arts I and II institutions, and 19 percent attend research universities, as defined by the Carnegie Classification. (See appendix table 2-3 and sidebar, "Carnegie Classification of Academic Institutions.") The demographic and college attendance patterns of the student population are changing. More than 50 percent of all undergraduates are age 22 or older, almost 25 percent are age 30 or older, and 40 percent of all students are attending college part time (Edgerton 1997).

Traditional Institutions of Higher Education

The Carnegie Foundation for the Advancement of Teaching (1994) has clustered institutions with similar programs and purposes to better describe the diverse set of traditional institutions serving various needs. The 2000 Carnegie Classification is under review, and new categories are being defined that combine doctoral and research universities. The changes omit references to the amount of research support different institutions have received (McCormick 2000). For the 1997/98 academic year enrollment and degree data used in this chapter, the former 1994 Carnegie Classification applies.

Enrollment in U.S. Higher Education by Type of Institution

Overall enrollment in U.S. institutions of higher education increased from 7 million in 1967 to 15 million in 1992 and then continued essentially unchanged through 1997. (See figure 2-4.) The expansion period represented an average annual growth rate of 3 percent, but growth rates differed greatly by type of institution. For example, two-year colleges grew at twice this rate and accounted for the largest share of the growth, from 1.5 million students in 1967 to 5.5 million in 1997 (including full- and part-time students).[2] By 1997, enrollment in two-year colleges was 38 percent of total higher education enrollment. In contrast, total student enrollment in research universities I grew more modestly, from 1.5 million students in 1967 to 2.1 million in 1992, with fluctuations around 2.1 million enrollments until 1997. Research universities enroll only 19 percent of the students in higher education, but they play the largest role in S&E degree production. (See figure 2-3 and appendix table 2-5.) Enrollment in higher education is expected to increase in the first decade of the 21st century because of a 13 percent increase in the college-age cohort during this period. (See appendix table 2-1.)

S&E Degree Production at All Levels of Higher Education by Type of Institution

Research-intensive universities produce most of the engineering degrees and a large proportion of natural and social science degrees at both the graduate and undergraduate levels. (See figures 2-5 and 2-6.) In 1998, the nation's 127 research universities awarded more than 42 percent of all S&E bachelor's degrees and 52 percent of all S&E master's degrees. In addition, comprehensive and liberal arts I institutions awarded significant numbers of bachelor's and master's degrees in S&E. Associate degrees awarded by community colleges accounted for only a small percentage of total S&E degrees awarded but serve other important functions.

S&E Faculty by Type of Institution

More than 1.1 million faculty teach in the approximately 3,400 degree-granting institutions of higher education. A large proportion (approximately two-fifths) of all faculty work part time. Some institutions rely on part-time faculty to a greater degree than others; almost two-thirds (65 percent) of faculty at public two-year institutions hold part-time appointments, and approximately one-fifth of faculty at public research institutions work part time. (See text table 2-1.)

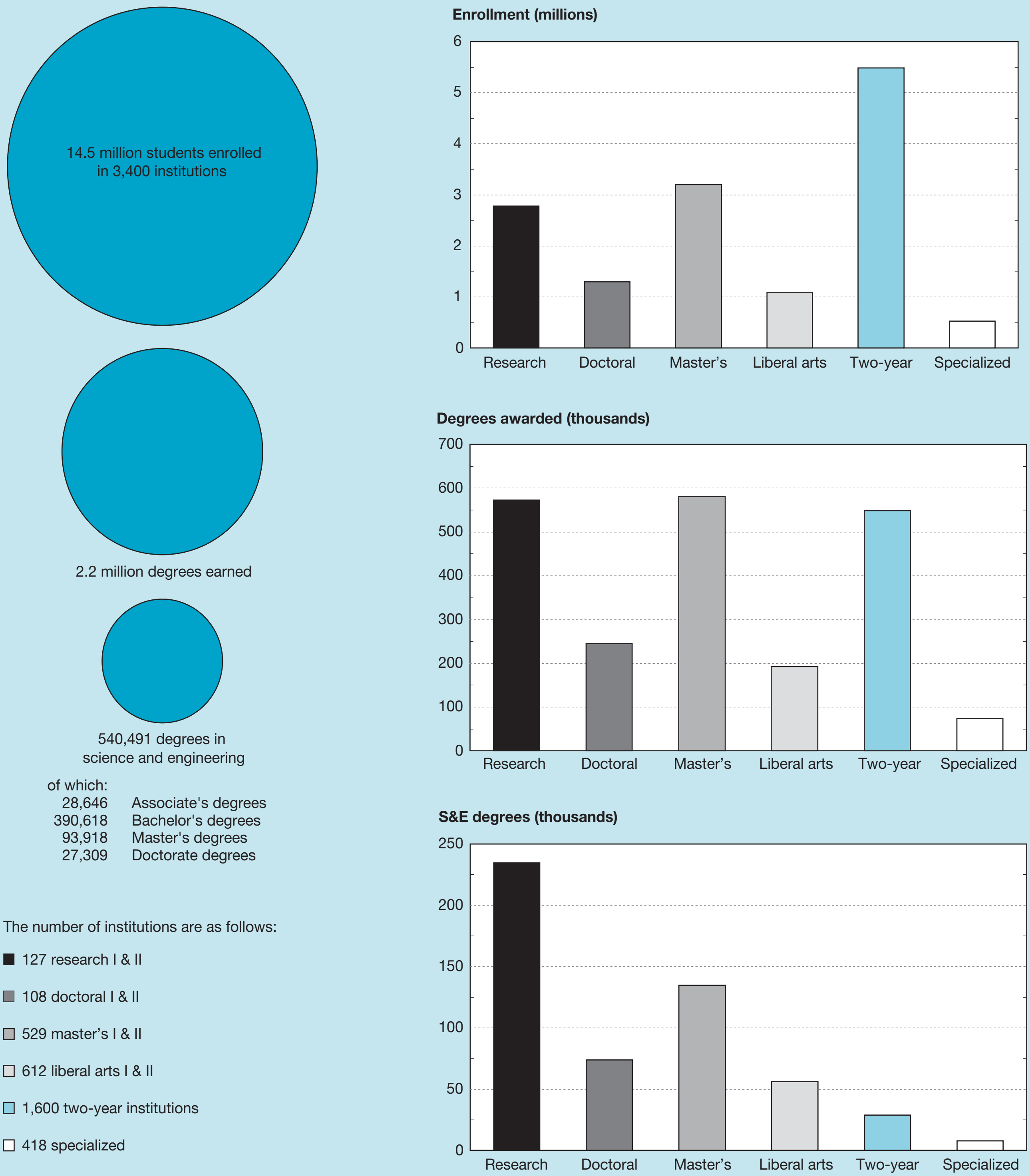
Underrepresented minority faculty in S&E fields are more concentrated at the associate level or in part-time positions at four-year institutions. They constituted only 6 percent of the full-time faculty who teach engineering and computer sciences at four-year institutions but 10 percent of the full-time faculty teaching subjects in these fields at community colleges. (See text table 2-2 and appendix table 2-6.)

Community Colleges

Community colleges serve a diverse student population and have a broad set of missions: they confer certificates and

[2]An additional 5 million students are estimated to be enrolled in noncredit courses in community colleges and are not counted in the overall enrollment in higher education.

Figure 2-3.
Profile of U.S. higher education by students, institutions, and degrees at all levels: 1998



NOTES: The 355 institutions classified as "other" are not included. Enrollment data are for fall 1997; degree data are for 1998.

See appendix tables 2-3, 2-4, and 2-5.

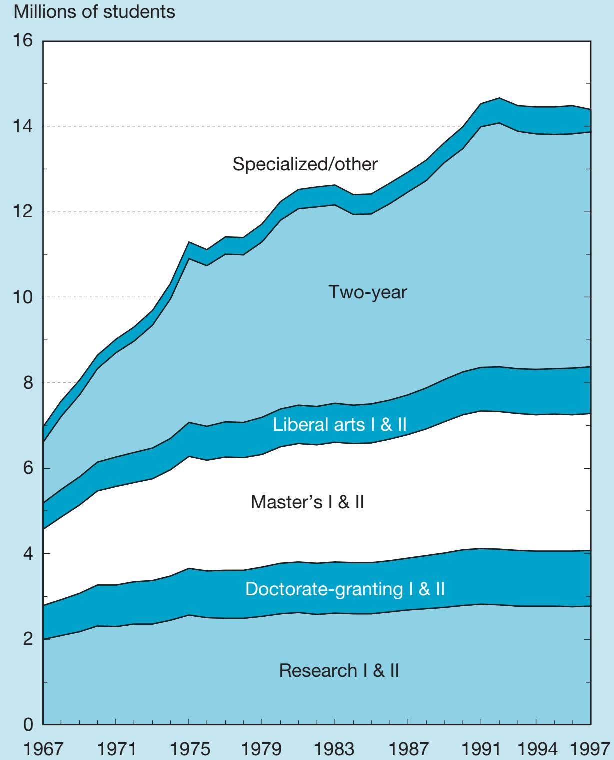
Science & Engineering Indicators – 2002

Carnegie Classification of Academic Institutions

- **Research universities I** (89)* offer a full range of baccalaureate programs, are committed to graduate education through the doctorate level, award 50 or more doctoral degrees, and receive $40 million or more in Federal research support annually.
- **Research universities II** (38) are the same as research universities I, except that they receive between $15.5 million and $40 million in Federal research support annually.
- **Doctorate-granting I** (50) institutions offer a full range of baccalaureate programs, are committed to graduate education through the doctoral degree, and award 40 or more doctoral degrees annually in at least five academic disciplines.
- **Doctorate-granting II** (58) institutions award 20 or more doctoral degrees annually in at least one discipline or 10 or more doctoral degrees in three disciplines.
- **Master's (comprehensive) universities and colleges I** (438) offer baccalaureate programs and, with few exceptions, graduate education through master's degrees. More than 50 percent of their bachelor's degrees are awarded in two or more occupational or professional disciplines, such as engineering and business administration. All of the institutions in this group enroll at least 2,500 students.
- **Master's (comprehensive) universities and colleges II** (91) enroll between 1,500 and 2,500 students.
- **Baccalaureate (liberal arts) colleges I** (162) are highly selective, primarily undergraduate colleges that award more than 40 percent of their bachelor's degrees in the liberal arts and science fields.
- **Baccalaureate (liberal arts) colleges II** (450) award fewer than 40 percent of their degrees in the liberal arts and science fields and are less restrictive in admissions than baccalaureate colleges I.
- **Associate of arts colleges** (1,155) offer certificate or degree programs through the associate degree level and, with few exceptions, offer no bachelor's degrees.
- **Professional schools and other specialized institutions** (418) offer degrees ranging from bachelor's to doctoral. At least 50 percent of the degrees awarded by these institutions are in a single specialized field. Institutions include theological seminaries, Bible colleges, and other institutions offering degrees in religion; medical schools and centers; other health profession schools; law schools; engineering and technology schools; business and management schools; art, music, and design schools; teachers' colleges; and corporate-sponsored institutions.

* The number of institutions is given in parentheses. For the number of institutions that award science and engineering degrees, by degree level and institution type, see appendix table 2-4.

Figure 2-4.
Enrollment in U.S. higher education, by institution type: 1967–97



NOTE: Enrollment data include part-time students.

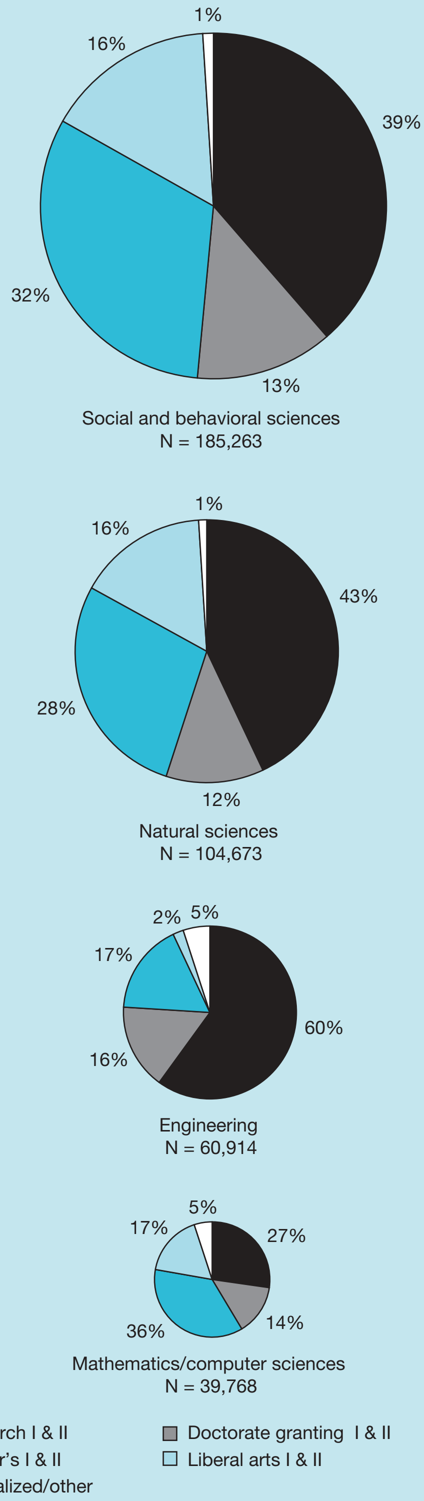
See appendix table 2-3. *Science & Engineering Indicators – 2002*

associate degrees, serve as a bridge for students to attend four-year colleges, offer an array of remedial courses and services, and enroll millions of students in noncredit and workforce training classes (Bailey and Averianova 1999). Community colleges are an accessible and low-cost group of institutions for lifelong learning. In 1998, 63 percent of the students in community colleges were enrolled part time, and more than 60 percent of these part-time students were older than age 25; in general, enrollment in remedial courses includes a significant number of older adults taking refresher courses (Phillippe and Patton 1999; American Association of Community Colleges 2001).

The role of community colleges as a bridge to four-year schools is difficult to determine because many students transfer to four-year schools before earning an associate degree.

Approximately 25 percent of community college students transfer to four-year institutions, but percentages differ by field and by state. Eighteen percent of physical science students attending four-year schools in 1994 had previously attended a community college, and 15 percent of those earning bachelor's degrees in computer sciences in 1994 had also earned associate degrees (U.S. Department of Education 1998). In Indiana, 67 percent of teachers surveyed took community college courses as part of their formal education. Some

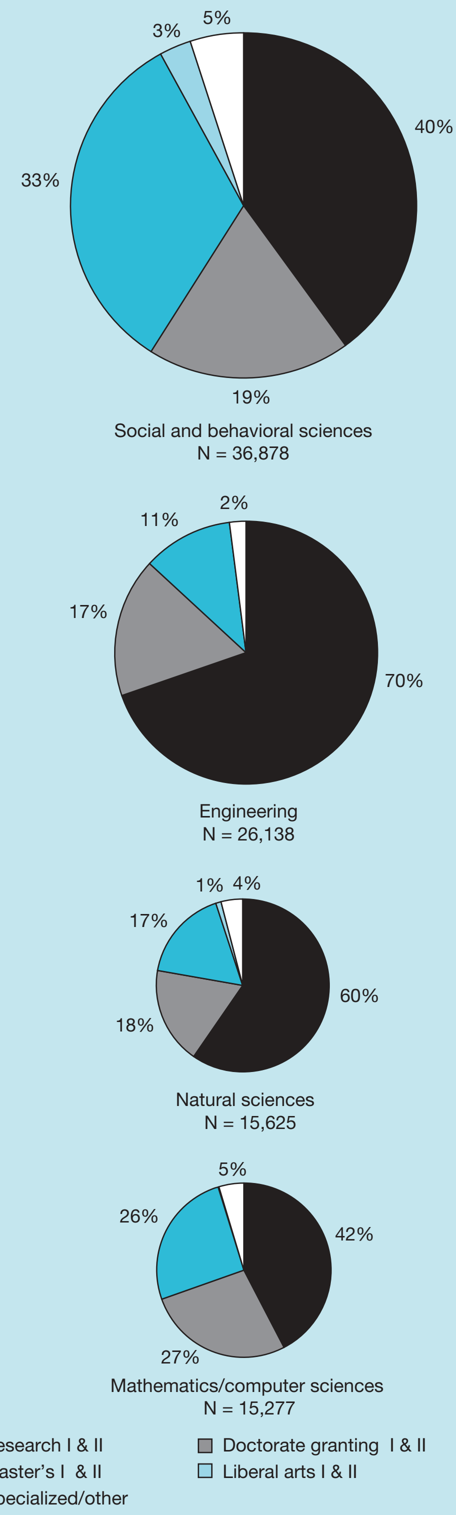
Figure 2-5.
Bachelor's degrees awarded in S&E, by institution type: 1998



NOTE: Natural sciences include physics, chemistry, astronomy, earth, atmospheric, ocean, biological, and agricultural sciences.

See appendix table 2-4. *Science & Engineering Indicators – 2002*

Figure 2-6.
Master's degrees awarded in S&E, by institution type: 1998



NOTE: Natural sciences include physics, chemistry, astronomy, earth, atmospheric, ocean, biological, and agricultural sciences.

See appendix table 2-4. *Science & Engineering Indicators – 2002* states encourage students to begin a bachelor's program at a community college: 50 percent of students in the California State University system attended a community college before entering a bachelor's degree program at a four-year institution. In addition, 75 percent of upper division education majors in the California State University system began their studies at community colleges (American Association of Community Colleges 2001; Pierce 2000; and Chancellor's Office 1999).

Text table 2-1.
Distribution of faculty employment status by type of institution: 1999
(Percentages)

Institution type	Full time	Part time
All institutions	57	43
Research		
Public	79	21
Private	69	31
Doctoral		
Public	72	28
Private	49	51
Master's		
Public	64	36
Private	50	50
Liberal arts, private	63	37
Two-year, public	35	65
Other	53	47

NOTE: Faculty includes all instructional staff.

SOURCE: U.S. Department of Education, National Center for Education Statistics, "1999 National Study of Postsecondary Faculty" (Washington, DC, 2001).

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Of all students in higher education in 1997, minority populations were concentrated in community colleges as follows: 46 percent of Asians/Pacific Islanders, 46 percent of blacks, 55 percent of Hispanics, and 55 percent of American Indians/Alaskan Natives (Phillippe and Patton 1999). A recent study indicates that minority students attending community colleges are more likely to transfer to selective four-year institutions than their colleagues who begin their academic career at a four-year school. Also, the completion rate for these transfer students is comparable with that of transfer students from other colleges (Eide, Goldhaber, and Hilmer, forthcoming).

The importance of community colleges in advancing the nation's technical workforce is indicated by the number of associate degrees and certificates in S&E fields and the number of information technology (IT) workers reporting "some" college experience. See sidebar, "Role of Community Colleges in Expanding Supply of Information Technology Workers."

New Modes of Delivery

The number of earned degrees from traditional institutions does not adequately represent the knowledge being acquired by students in science, engineering, mathematics, and computer sciences in a given year. Lifelong learning and various new ways of acquiring knowledge are not all quantified or captured in current education indicators. No indicators ad-

Text table 2-2.
Postsecondary faculty in S&E, by race/ethnicity, field, and employment status: 1999
(Percentages)

Race/ethnicity and field	Full time: 2-year institutions	Full time: 4-year institutions	Part time, 4-year institutions
White			
Natural sciences and mathematics	82.4	83.3	80.8
Life sciences	88.5	85.0	91.4
Social and behavioral sciences	80.6	86.1	86.6
Engineering and computer sciences	85.4	80.5	82.7
Asian/Pacific Islander			
Natural sciences and mathematics	3.8	10.9	5.6
Life sciences	4.9	9.7	6.0
Social sciences	1.8	4.8	2.2
Engineering and computer sciences	4.9	13.5	7.2
Underrepresented minorities			
Natural sciences and mathematics	13.9	5.8	13.7
Life sciences	6.6	5.3	2.7
Social sciences	17.6	9.1	11.2
Engineering and computer sciences	9.7	6.0	10.0

NOTE: Natural sciences include physics, chemistry, astronomy, and earth, atmospheric, and ocean sciences.

SOURCE: U.S. Department of Education, National Center for Education Statistics, "1999 National Study of Postsecondary Faculty" (Washington, DC, 2001).

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Role of Community Colleges in Expanding Supply of Information Technology Workers

A recent study on the educational background of the expanding information technology (IT) workforce indicates that the contribution of associate degree holders to that pool has declined. The number of IT workers with associate degrees newly entering the workforce (IT workers 25–34 years of age) declined by more than 20 percent from 1994 to 1999. (See text table 2-3.) However, case studies of selected community colleges (American River in Sacramento, California, and Bellevue in Bellevue, Washington) show other contributions of these institutions to the nation's IT workforce (Lerman, Riegg, and Salzman 2000).

Enrollment in IT classes at these institutions continues to grow, as does the proportion of workers reporting that they have some college background but lack a formal degree. Between 1994 and 1999, the number of IT workers who had "some college" experience but no degree increased by about 43 percent. (See text table 2-3.) Although there is no way to know where the "some" college group is getting its schooling, IT workers who report some college education have probably received their related education from community colleges.

Much of the information on IT education contributed by community colleges does not appear in the statistics on IT-related associate degrees and certificates. Many students leave before obtaining a degree or certificate, either because they find employment or because they already have a four-year degree and are not concerned with an associate degree or a certificate. At Bellevue Community College in 1998, 827 students were enrolled in IT programs, but only 67 graduated with associate degrees and 21 graduated with certificates. The lack of interest in obtaining a degree may partly reflect the fact that many (198) Bellevue IT students (24 percent of the total IT enrollees) had already earned a four-year degree. Interviews with faculty indicate that 85 percent of students who left their institutions without a degree or certificate were employed. The colleges reported that almost one-third of all IT program participants between 1994 and 1997 left before completing even 10 class credits (Lerman, Riegg, and Salzman 2000).

Text table 2-3.
IT workforce, by education and age: 1994 and 1999

Education and age	1994 Number	1994 Percent	1999 Number	1999 Percent
Total, all IT workers	1,668,000	100.0	2,347,000	100.0
Less than high school graduate	11,000	0.7	12,000	0.5
High school graduate	141,000	8.5	195,000	8.3
Some college	267,000	16.0	381,000	16.2
Associate of arts	182,000	10.9	205,000	8.9
Bachelor's degree	793,000	47.5	1,143,000	48.7
Graduate degree	274,000	16.4	411,000	17.5
25- to 34-year-old IT workers	702,000	100.0	880,000	100.0
Less than high school graduate	3,000	0.4	4,000	0.5
High school graduate	49,000	7.0	48,000	5.5
Some college	76,000	10.8	125,000	14.2
Associate of arts	85,000	12.1	67,000	7.6
Bachelor's degree	386,000	55.0	466,000	53.0
Graduate degree	103,000	14.7	170,000	19.3

SOURCE: R.I. Lerman, S.K. Riegg, and H. Salzman, "The Role of Community Colleges in Expanding the Supply of Information Technology Workers" (Washington, DC, The Urban Institute, 2000).

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equately capture the nontraditional education acquired through industrial training, certificate programs, and distance learning. See sidebars, "New Horizons in Science and Engineering Education" and "Certificate Programs."

Limited data exist on student participation and completion rates for many of the cited mechanisms. For example, national education surveys do not capture the number and types of students enrolled in most certificate programs or those taking an array of related courses that could lead to upgraded job skills but not a formal degree. Such data are needed to gain a more complete picture of the nation's S&E education and training system.

New Horizons in Science and Engineering Education

The advent of technologies that support distance education and the demands of science and engineering (S&E)-related business and industry (e.g., information technology (IT) and bioinformatics) have been accompanied by the development of alternative mechanisms of delivering higher education, such as industrial learning centers and distance education. An increasing number of people are taking advantage of these alternatives either to enter new fields or to upgrade their skills in existing but rapidly changing fields. Many of the mechanisms, whether offered through traditional institutions (whose data are captured in national education surveys) or outside those institutions, could be defined as within the realms of continuing education or workplace training.

Industrial Learning Centers

Currently, approximately 2,000 industrial learning centers exist in the United States (compared with 400 in 1986), and this number will likely continue to increase rapidly. In general, these centers serve employees within a specific company or industry and are business management oriented. Some large industries, however, have internal training at the level of higher education in engineering and design. For example, the so-called "Motorola University" has an annual $2 billion budget (similar to that of the University of Indiana and Purdue University) and contracts with 1,200 faculty worldwide. These faculty teach business and engineering wherever Motorola is designing innovative products

Many industrial centers are partnered with traditional institutions of higher education and use traditional courses and university faculty to supplement industry-developed training courses (Meister 2001). For example, Motorola University has partnerships with traditional institutions for sharing technology, faculty, and facilities. Motorola is part of a Ph.D. program at the Indian Institute of Information Technology (IIIT) in Hyderabad, India, and degree programs at Morehouse University in Atlanta and Roosevelt University in Chicago. At the associate level, Motorola University works with faculty from Pretoria University's engineering school in South Africa (Wiggenhorn 2000).

Distance Education

Distance education is a rapidly growing and relatively unregulated aspect of higher education. In 2001, the Regional Accrediting Commissions issued their first set of guidelines for the evaluation of electronically offered degree and certificate programs (Regional Accrediting Commissions 2001). Comprehensive data are not available on the number of undergraduate and graduate S&E degrees or the number of programs fully or partially offered through distance education. However, interest in delivering and taking S&E courses and entire programs via distance education is growing (Office of Government and Public Affairs 2000). In 1997, more than 50,000 different on-line courses were offered by postsecondary institutions; 91 percent were college-level credit courses. Approximately 1.6 million people registered for on-line courses in 1998, 82 percent in college-level credit courses at the undergraduate level (University Continuing Education Association 2000). In many ways, these programs are comparable to correspondence programs offered either by for-profit institutions, such as the International Correspondence Schools, or by traditional universities through their correspondence or continuing education units. In IT-related certification programs, this method of delivering postsecondary education may be one of the dominant modes, at least on an international basis.

Undergraduate S&E Students and Degrees in the United States

Key challenges for undergraduate education in S&E include preparing teachers for K–12 and college levels (Committee on Science and Mathematics Teacher Preparation (CSMTP) 2001), preparing scientists and engineers to fill needed workforce requirements and provide the capacity for long-term innovation (Romer 2000; NSTC 2000), providing understanding of basic science and mathematics concepts for all students, and measuring what students learn (National Center for Public Policy and Higher Education 2000). These challenges relate to the nation's ability to retain its innovation capacity and international position in S&T.

The need for undergraduate teaching that could attract and retain students in S&E fields has been widely noted and discussed (National Commission on Mathematics and Science Teaching for the 21st Century 2000). Professional associations (Gaff et al. 2000; Sigma Xi 1999), private foundations (Kellogg Commission on the Future of State and Land-Grant Universities 1997), public officials (National Governors Association 2001), and universities themselves (NSF/EHR Advisory Committee 1998) have each expressed concern regarding the delivery of undergraduate education.

The nation must also meet its growing need for K–12 teachers, particularly in mathematics and science. Recent studies indicate that in the upcoming decade, the nation's school districts will need to hire 2.2 million new teachers (U.S. Department of Education 1999), including 240,000 middle and high school mathematics and science teachers (National Commission on Mathematics and Science Teach-